

To: Fred Stroud

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**PROPOSAL FOR HYDROGEOLOGIC INVESTIGATION AT SAAD
TROUSDALE DRIVE SITE, NASHVILLE, DAVIDSON COUNTY,
TENNESSEE**

Crawford and Associates, Inc.

June 12, 1994

Crawford and Associates, Inc. agrees to perform the hydrogeologic investigation at the Saad Trousdale Drive Site, Nashville, Tennessee according to the Scope of Work (Section 3) of the Request for Proposal prepared by Roy F. Weston, Inc., May 1994, for the set price indicated on the Price Quotation Form.

It is very difficult to give a set price bid for this type of investigation previous to performing the Karst Hydrogeologic Inventory and Potentiometric Surface Investigation. At this point, the area to be included in the investigation could be larger than that indicated on Figure 1 and the number of springs to be monitored could also be larger than 20, the number used for this bid. If after performing the Hydrogeologic Inventory, it is determined that additional springs must be monitored, those additional dye monitoring sites will have to be included under a separate bid.

This bid is based on the following:

1. Karst Hydrogeologic Inventory and Potentiometric Surface Investigations to include the area indicated on Figure 1.
2. A maximum of 20 dye receptor locations at springs, surface streams and cave streams.
3. Two ISCO automatic water samplers. One to be located at Croft Spring and the other on the spring that continuously flows from the CSX Radnor Yard storm sewers or on a spring near the head of Brown's Creed. After the first three dyes are injected, samples will be collected at a two-hour interval for two days, then a four-hour interval for 12 days, then an eight-hour interval for 16 days. This sequence will be repeated after the second three dyes are injected.
4. Dye receptors are to be changed weekly from the time the backgrounds are collected around July 17, until the last time they are collected around September 10. Therefore, the dye receptors will be changed a total of nine times.
5. Dyes will be injected into existing monitoring wells or dye injection pits excavated with a trackhoe.
 - A) The first three dyes, probably Rhodamine WT, Eosine and Timopal CBS-X, will be injected into SSS1 at the Saad Site, SSLN1 or BH-6 at the CSX Radnor Yard sinkhole area, and at one of the wells at the GE Maintenance Facility Site.
 - B) After the completion of the first three traces (probably about four weeks), the second three dyes, probably Fluorescein, Direct Yellow 96 and Rhodamine WT, will be injected at three additional locations. This is assuming that the dyes from the first three traces go to Croft Spring and/or Browns Creek where the ISCO samplers will be placed. If not, at least one

EXHIBIT B

sampler will have to be moved and one or more traces repeated in order to obtain a quantitative trace with a dye breakthrough curve. The selection of the second three dye injection points should not be made until the first three are completed. Then we will know where we need additional groundwater flow information, particularly to establish groundwater divides. Possible sites include wells BH-2 on the north side of the CSX Roundhouse and BH-10. Another location may be selected somewhere between the GE Site and the Saad Site. If there are no existing monitoring wells in these locations suitable for dye injection, a trackhoe (excavator) will be used to dig a dye injection pit. Although in some areas the depth to bedrock may be too deep to install a dye injection pit, well data indicates that in many areas it is less than 20 feet.

RESEARCH PROCEDURE

The research procedure to be used is one which Crawford has used to trace the flow of groundwater in karst aquifers on numerous occasions since 1970. It consists of the following:

1. Karst Hydrogeologic Inventory. This includes locating all springs, caves, cave streams, karst windows, significant sinkholes (usually those that are deep with steep sides), sinking streams, and lineaments (often a line of sinkholes).
2. Installation of Background Dye Receptors. The passive dye receptors to be used are: a) small packets of activated coconut charcoal contained with aluminum or fiberglass screen mesh and b) 2 x 4 inch bundles of unbleached cotton. These are placed in all springs, cave streams, karst windows, surface streams, and selected monitoring wells and water wells and left for approximately one week. They are then replaced with new receptors and the background receptors are analyzed in the lab along with water samples collected at each site for background fluorescence. Background fluorescence will be considered in selecting dyes to be used for the investigation.
3. Mapping of Potentiometric Surface of the Uppermost Karst Aquifer. All accessible water wells and monitoring wells in the area will be measured during a dry period and the depth to water subtracted from the ground surface elevation which is usually estimated from a 10 foot contour interval 7.5 minute USGS topographic quadrangle map. Elevations at selected wells, springs and streams will be determined by leveling from benchmarks.
4. Dye Injection. After the completion of the hydrogeologic inventory, the potentiometric surface map, the analysis of the background dye receptors, and the placement of dye receptors in all springs, karst windows, cave streams, surface streams and selected monitoring and water wells, dye will be injected directly into a sinking stream, sinkhole, well, or hole excavated in the soil. Water from a hose or a water truck will be used to flush the dye past the soil into a bedrock crevice which leads to a cave stream. Usually about 500 gallons of water are injected into the hole to make sure that it drains sufficiently and to wet the soil so that less dye will be sorbed by clays. The dye is then injected and flushed with at least 2,000

gallons of water. Usually three or four dye traces can be performed simultaneously by using different dyes.

The dyes usually used are:

- a) Eosine - Color Index: Acid Red 87
- b) Fluorescein - Color Index: Acid Yellow 73
- c) Optical Brightener - Tinopal CBS-X, Fabric Brightening Agent 351
- d) Rhodamine WT - Color Index: Acid Red 388
- e) Diphenyl Brilliant Flavine 7GFF - Color Index: Direct Yellow 96

These are standard dyes often used for dye traces in karst aquifers. They are safe for this purpose in the concentrations used both for human consumption and aquatic life (Smart, 1986).

5. Dye Receptor Analysis. Usually within 4 to 10 days (depending on weather and other factors) the dye receptors are replaced, and the ones collected are then analyzed for dye. The activated charcoal is washed and then half of it is treated with a 5:2:3 mixture of 1-propanol, concentrated ammonium hydroxide and distilled water (Smart, 1972), to elute Fluorescein, Eosine, and Rhodamine WT from the charcoal. The elutant is then compared with the elutant of the background receptor on a Shimadzu Spectrofluorophotometer RU 5000. The unbleached cotton dye receptors are washed to remove as much mud as possible, and then tested for Optical Brightener and Direct Yellow 96 under a long-wave ultraviolet lamp. Optical brightener, if present, will glow a blue-white, and Direct Yellow 96, if present, will glow a pale yellow.
6. Quantitative Dye Trace. This involves installing ISCO automatic water samplers at the hypothesized spring or springs. The collected samples are then analyzed on a Shimadzu Spectrofluorophotometer RU 5000. This provides a graph of the complete dye breakthrough curve at the spring or springs.
7. Report and Map of Groundwater Flow. This research will result in a map showing the following for the area in the vicinity of the site.
 - a) Groundwater elevations of all springs, monitoring wells and water wells measured.
 - b) Potentiometric surface of the water table aquifer.
 - c) All springs, cave streams, karst windows and sinking streams in the research area.
 - d) Generalized groundwater flow routes through the aquifer as determined from the dye traces and water table data.The report will discuss the hydrogeology of the site as determined by the dye trace, potentiometric surface and geologic investigations. This will include one or more hydrogeologic cross-sections showing groundwater flow through the karst aquifer from dye injection points to springs.

CRAWFORD AND ASSOCIATES PERSONNEL

Principal Investigations:

Dr. Nicholas C. Crawford - see Vita

Dr. Christopher G. Groves - see Vita

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SADD WASTE OIL SCHEDULE

TENATIVE

Parr conversation w/ Rick Crawford

TASK #	Project Work Plan	7/24/94
#1	LITERATURE Review	7/15 - 7/30/94
#2	PERMITS for Dye Tracing	7/24 - 7/30/94
#3	WORKING Base Map	7/30/94
#4	SAMPLES + PREP	8/1 - 8/5/94
#5	HYDRO - INVENTORY	8/1 - 8/5/94
#6	BACKGROUND RECEPTORS	8/1 - 8/5/94
#7	POTENTIOMETRIC SEC. INV.	8/11 to 8/16
#8	CAPACITY TEST for Injection Wells	
#9	ISCD WATER SAMPLES	8/12/94
#10	RETRIEVE BACKGROUND Dye RECEPTORS	
#12	Dye Injection #1	9/9/94
#13	3 - TRACES for probable work period	
	Dye Injection #2	
	3 More Dyes	

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